



Space @ Virginia Tech

Center for Space Science and Engineering Research

Space@VT Cubesat Efforts

Presented at the 2012 AMSAT Space Symposium

Presenters:

Robert W. McGwier, N4HY

Zachary J. Leffke, KJ4QLP



VirginiaTech
Invent the Future

<http://www.space.vt.edu/>



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Virginia Tech ECE Research Professor

Hume Center for National Security and Technology

Director of Research

Former Vice President of Engineering, AMSAT



Zachary J. Leffke

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Virginia Tech Graduate Student, MSEE

Hume Center for National Security and Technology

Agenda

- Space@VT Overview
 - Research Interest and Capabilities
 - Research Facilities
 - Project Examples
- Space@VT Cubesat Efforts
 - DUSTIE
 - LAICE
 - FOX-1
- Virginia Tech Cube Satellite Control Facility

- **Space@VT Overview**
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Our mission is to provide forefront research, instruction, and educational outreach in the fields of space science and engineering utilizing a holistic approach of theoretical modeling, advanced simulation techniques, space system and instrument design, and experimental data acquisition, analysis and interpretation.



Director
Professor Wayne Scales, Ph. D.



Assistant Director
Professor Robert Clauer, Ph. D.



- Collaboration between VT ECE and AOE
- 12 Virginia Tech Faculty Members (Including Dr. McGwier)
- 3 Research Associates
- Over 25 Graduate Students

Research Interests:

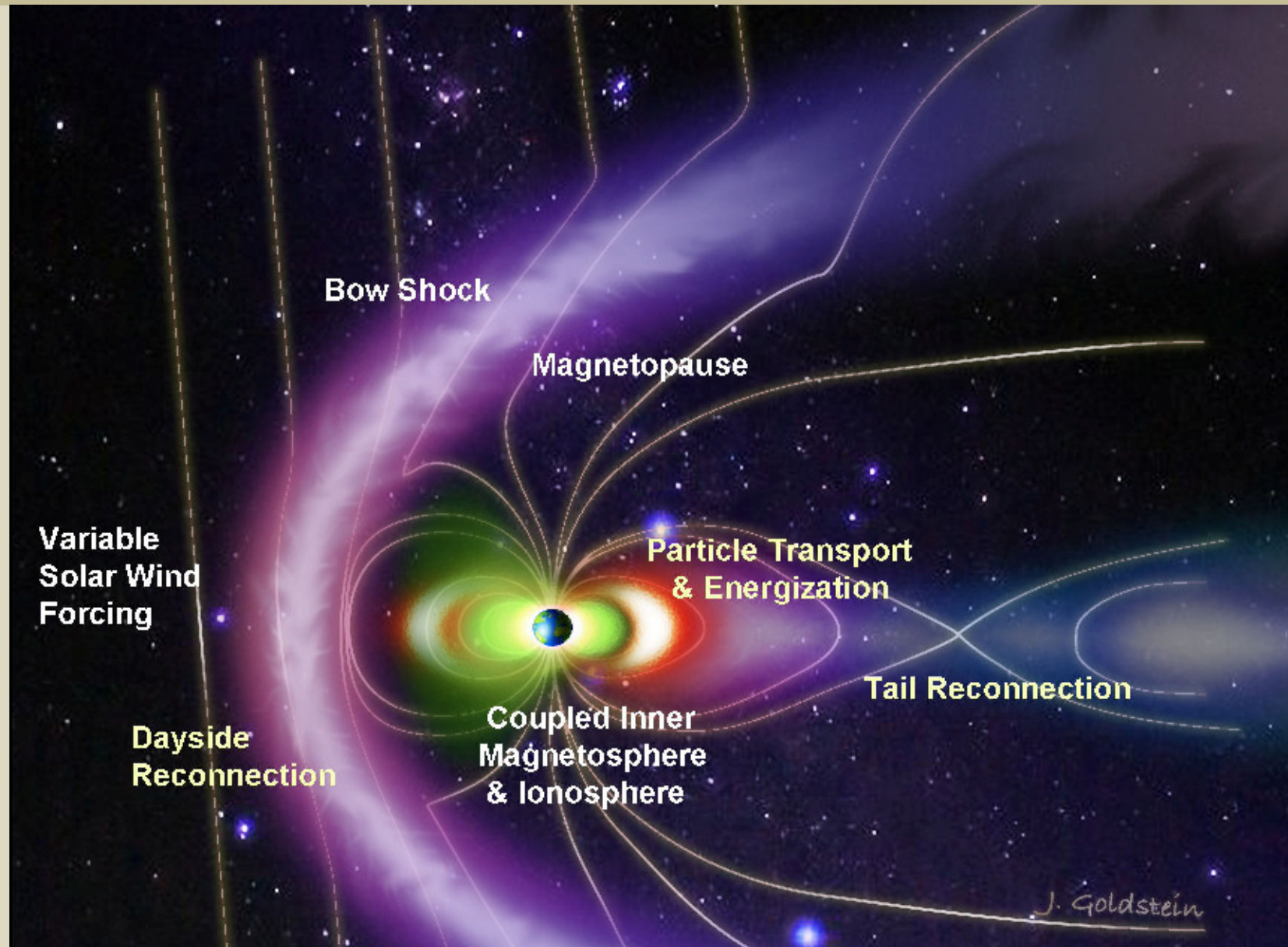
- Upper Atmospheric and Space Plasma Physics
- Space Weather Investigations
- Spacecraft Dynamics and Control
- Spacecraft Advanced Propulsion Techniques
- Spacecraft Environmental Interactions

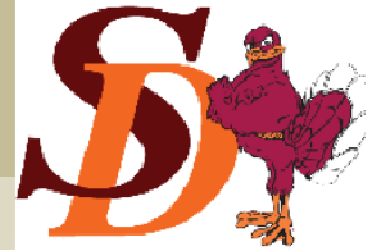
Research Capabilities:

- Satellite Mission Design and Remote Sensing
- Space-based Instrument Development
- Ground-based Instrument Development
- Spacecraft Modeling, Simulation, and Design
- Physics-based Modeling, Simulation, and High Performance Computing
- Global Navigation Satellite System Receiver Design

Research Facilities:

- Global Navigation Satellite System GNSS Laboratory
- Space Systems Simulation Laboratory
- Aeronomy/Remote Sensing Laboratory
- Advanced Space Computation Laboratory
- **SuperDARN Space Weather Radar Facility**
- Space Plasma Chamber
- **Magnetosphere - Ionosphere Science Team (MIST)**





- Over 25 Radar Locations around the world
- Operating Frequency: 8 – 20 MHz
- Field Of View: Polar Regions of Earth
- Observes the motion of charged particles (plasma) in the ionosphere and other effects.
- Provides insight into space weather hazards including high altitude radiation exposure and disruptions to communications networks, navigation systems (GPS), and the electrical power grid.
- Currently: 6 VT Faculty and Staff, 7 VT Graduate Students
- 13 Authored Publications, 19 Co-Authored Publications

Northern Radar Institutions:

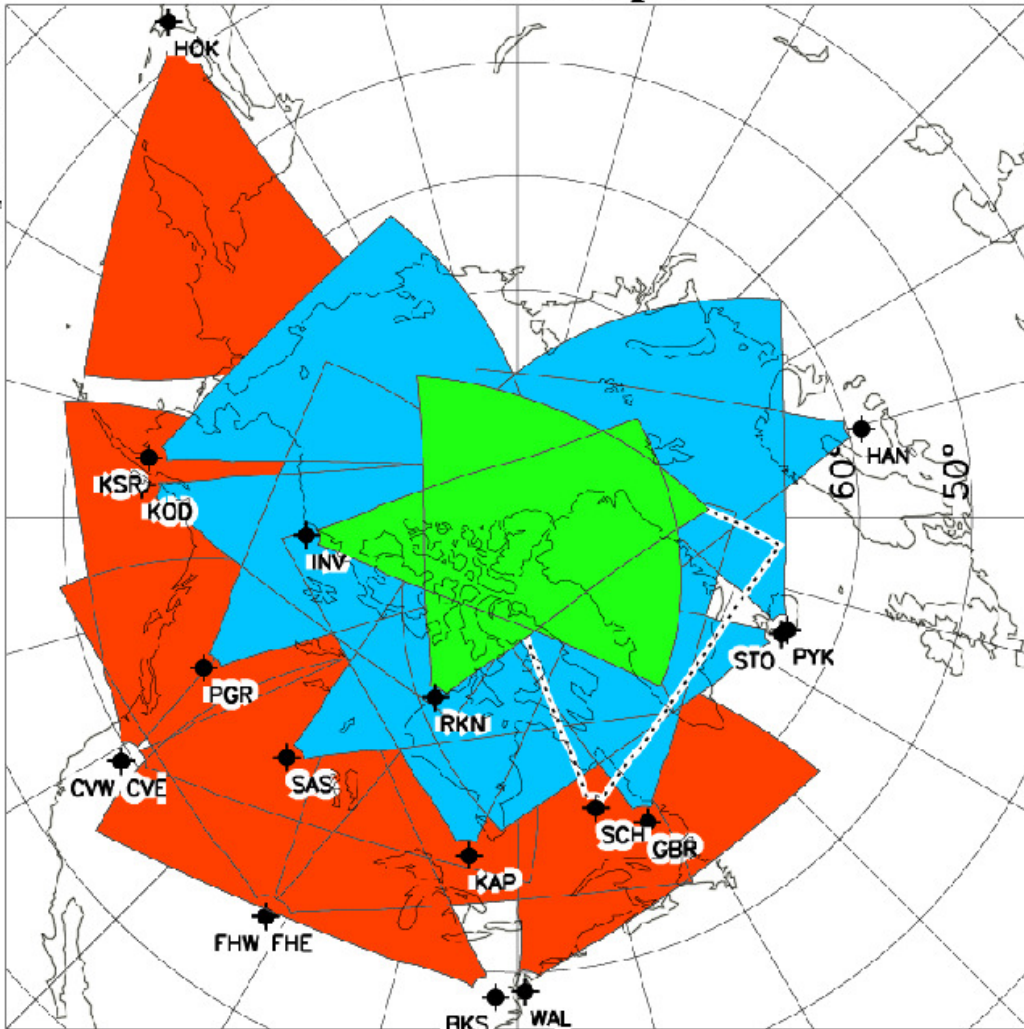
- Virginia Tech: 6 Radar Locations
- Dartmouth College
- University of Leicester
- Nagoya University
- University of Saskatchewan
- National Institute of Information and Communications Technology
- University of Alaska, Fairbanks
- CNRS/LPCE
- JHU Applied Physics Laboratory

Southern Radar Institutions:

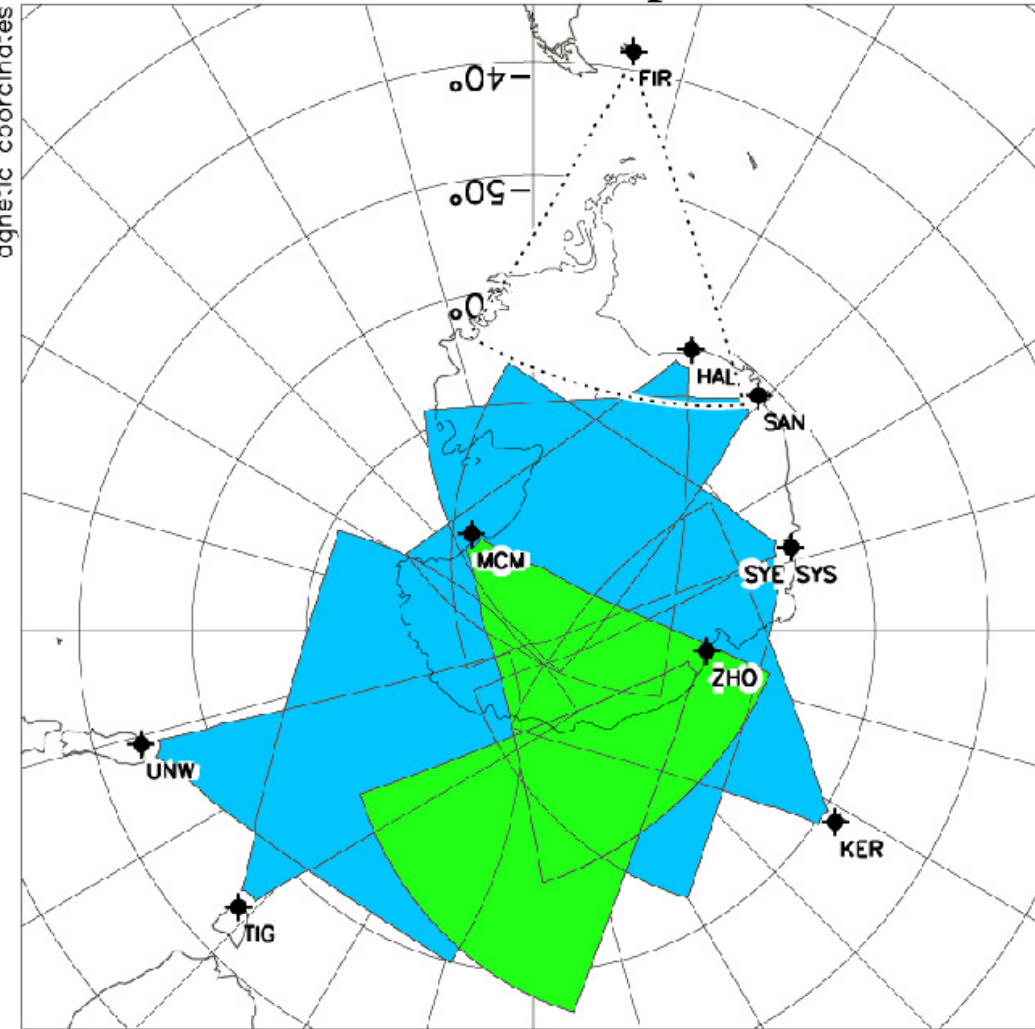
- British Antarctic Survey
- CNRS/LPCE
- University of Alaska, Fairbanks
- South African National Space Agency
- National Institute of Polar Research
- La Trobe University
- Polar Research Institute of China



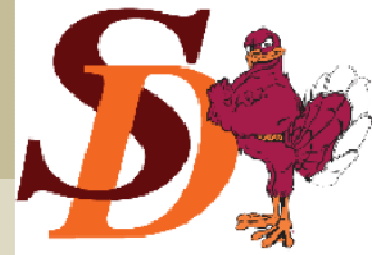
Northern Hemisphere



Southern Hemisphere



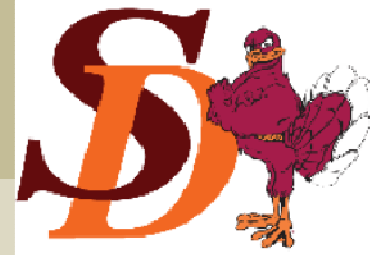
 Polar Cap  High-Latitude  Mid-Latitude  Out-of-Service



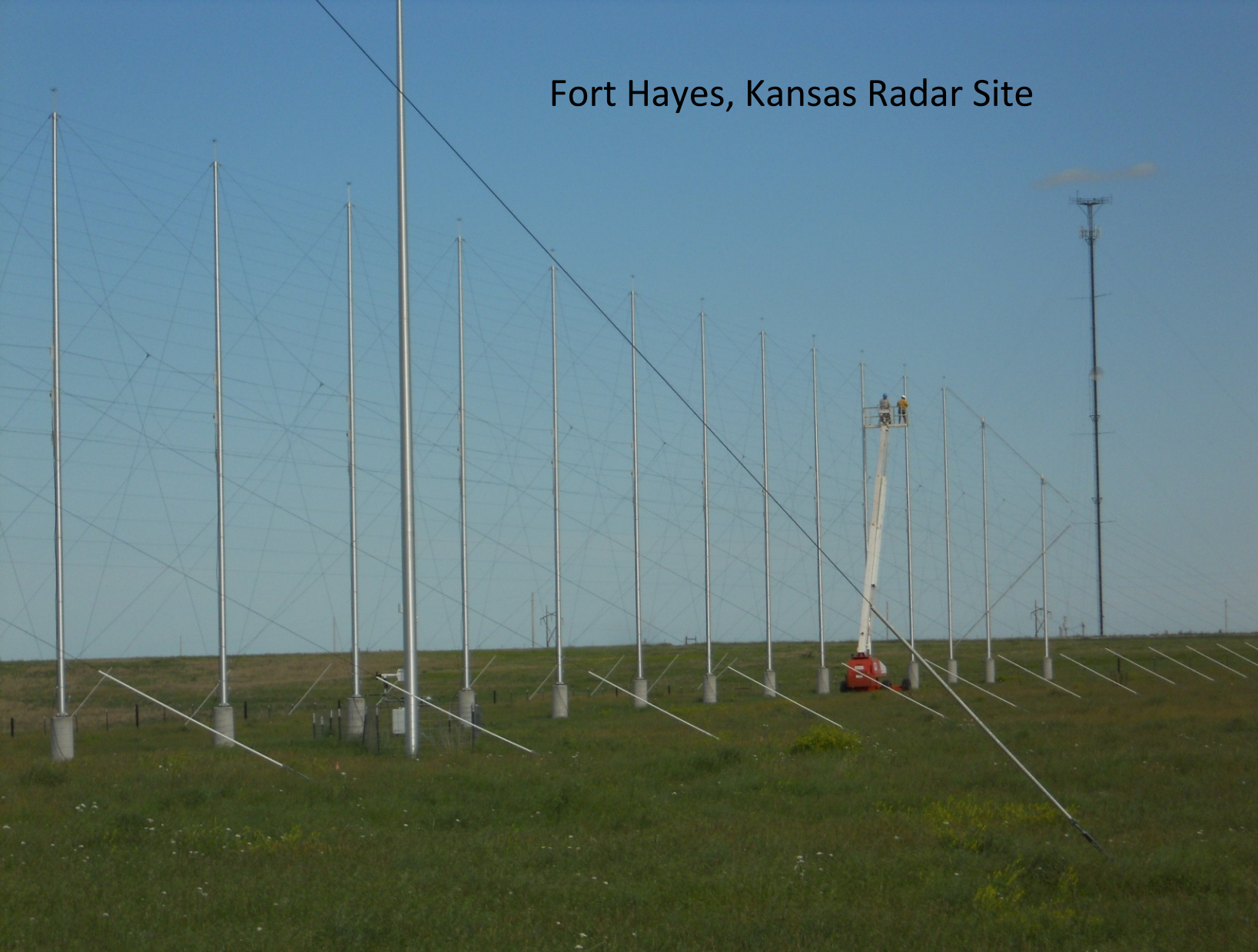
Blackstone, Virginia Radar Site

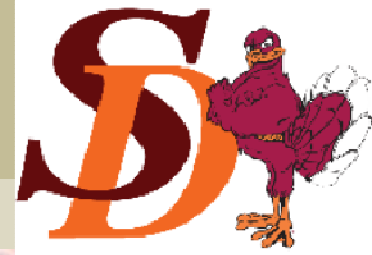


Kapuskasing, Canada Radar Site



Fort Hayes, Kansas Radar Site





Fort Hayes, Kansas Radar Site

We primarily investigate the interaction between the Earth's "magnetosphere" and its ionosphere. The magnetosphere is the cavity formed by the interaction between the solar wind and Earth's main magnetic field, that is generated by electric currents deep within the planet's core. The ionosphere is the top-most layer of the atmosphere, extending into space, where the atoms have been ionized by the ultraviolet rays from the Sun, forming a conductive "plasma". The magnetosphere is also filled with plasma. The regions of the magnetosphere that have magnetic field line "footprints" in either of two, oval-shaped regions in the ionosphere surrounding the polar caps collectively account for the aurora. Large-scale current systems and other effects carry momentum and energy from high to lower altitudes, resulting in electric fields and currents in the ionosphere. The driving force of this energy flow is the solar wind and the "Interplanetary Magnetic Field," known as the "IMF," which is carried outward from the Sun by the solar wind. The electric currents in the ionosphere produce variations in the magnetic field at the surface of the Earth. Measurements of these variations with magnetometers are often used to study the Magnetosphere-Ionosphere system.

Principal Investigator: C. Robert Clauer (Bob), Ph. D., Co-Director of Space@VT

AAL-PIP deployment team members around the AAL-PI system located at the South Pole (January 4, 2012)



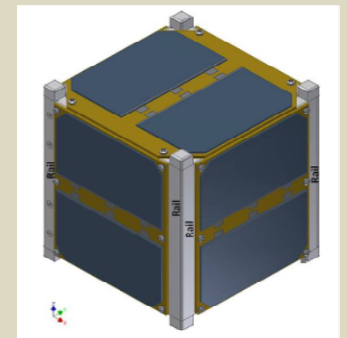
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Space@VT Overview

Cubesat Efforts

The Satellites

- DUST Sounder and Temperature Imager Experiment (DUSTIE)
Size: 3U
- Lower Atmosphere/Ionosphere Coupling Experiment (LAICE)
Size: 6U (2U x 3U or “Sixpack”)
- AMSAT FOX-1
Size: 1U



The Ride To Space

NASA Educational Launch of Nano Satellites Program (ELaNa)

Selection: February 2012

Launch Date: 2013/2014

Cubesats and Space@VT

DUST Sounder and Temperature Imager Experiment (DUSTIE)

VT Faculty: Dr. Scott Bailey & Dr. Robert McGwier

MISSION:

Determine the global distribution of cosmic smoke in the atmosphere. DUSTIE will use a digital camera to image the Sun at $0.420\ \mu\text{m}$ during spacecraft sunrise and sunset. This will provide measurements to characterize the smoke distribution over the altitude range of ~ 40 to $90\ \text{km}$.

(information from: <http://adsabs.harvard.edu/abs/2009AGUFMSM33C1575M>)



images from: <http://www.cubesatkit.com/content/news-2010.html>

VT Faculty: Dr. Greg Earle

MISSION:

“We’re basically trying to measure the wind in a vacuum.” Neutral particles move when the atmosphere changes temperature, like wind on the earth’s surface. Dr. Earle is developing a new kind of transducer to measure these neutral winds. The instrument is basically a parallel plate capacitor in which one plate is a flexible silicon membrane with a thin metal coating, change the distance between the plates, the capacitance changes.

(information from: Space@VT brochure, available at <http://www.space.vt.edu/>)



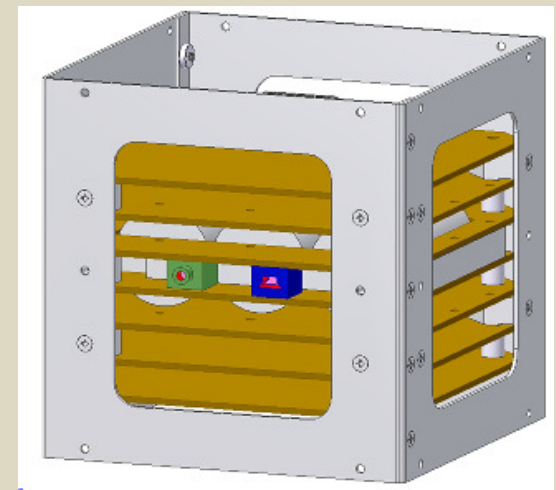
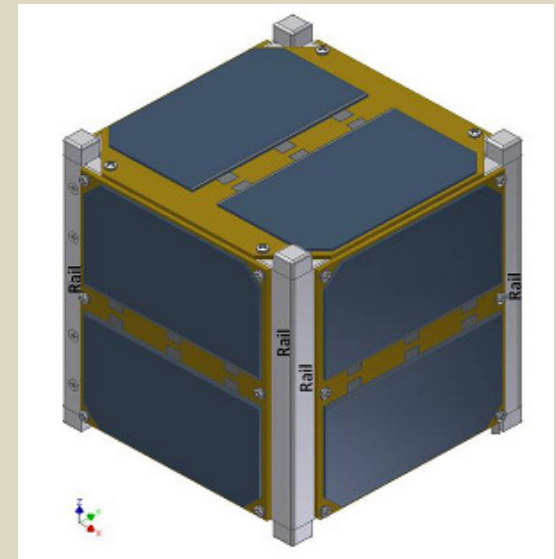
Project Leader: Anthony Monteiro

VT Faculty: Dr. Robert McGwier

MISSION:

Fox-1's Primary mission will be to carry an FM repeater operating in the amateur radio 70cm (uplink) and 2m (downlink) frequencies. This will provide a service similar to the now dead AO-51 communications services. In addition to this the cubesat will support a Penn State University 3-axis MEMS gyro sensor developed as a senior design project.

VT's Part of the Mission: Imaging Experiment (Not SSTV)



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Primary Mission:

To provide Cube Satellite Tracking Telemetry and Control (TT&C) services as well as science payload data services for Virginia Tech cube satellites as well providing support and capabilities to ongoing US government sponsored research programs here at Virginia Tech.

Secondary Mission:

To provide the same cube satellite services to other entities involved in cube satellite missions through cooperation via the Global Educational Network for Satellite Operations (GENSO) Network.

The Problem:

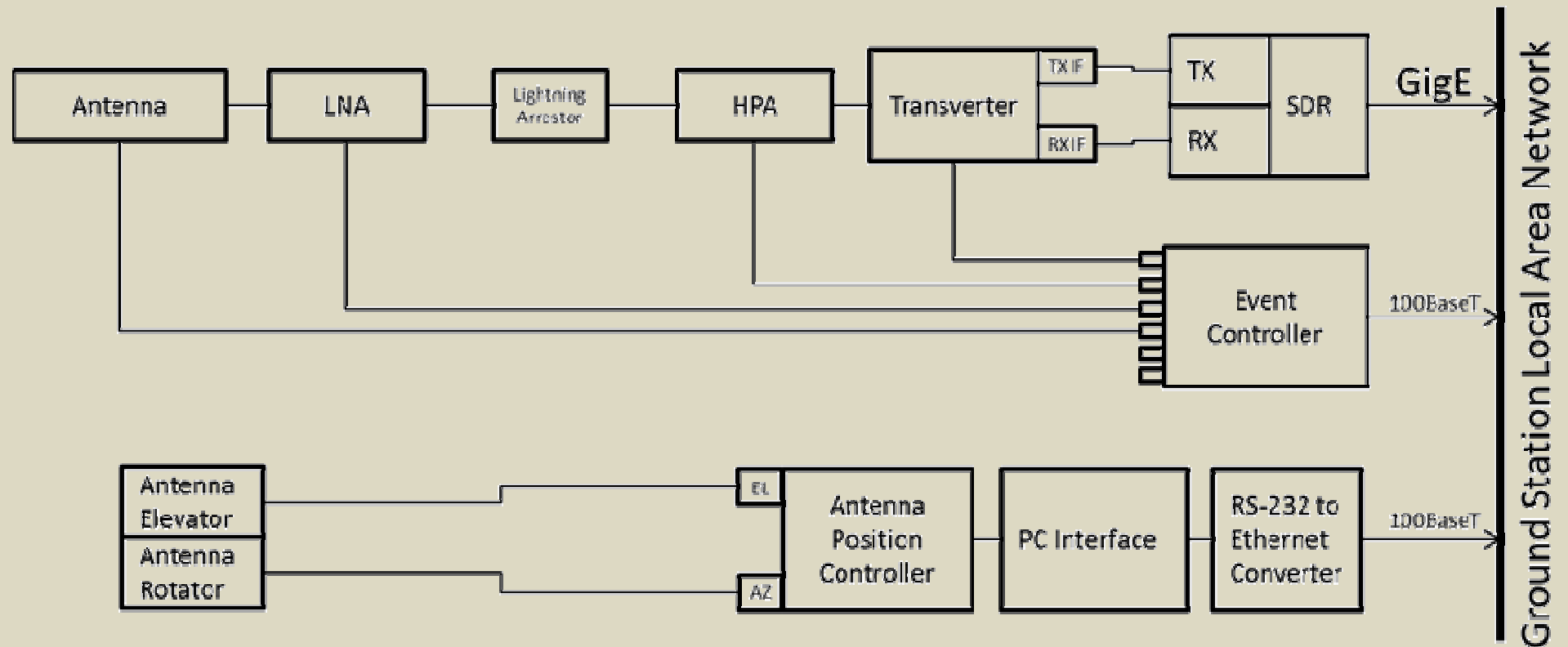
Diverse protocols and modulation schemes are used in currently existing cube satellites communications.

Virginia Tech Solution:

To utilize Software Defined Radio technology in conjunction with quality hardware in the ground control facility to accomplish the mission.

Virginia Tech Cube Satellite Control Facility

RF Chain and Control Chain



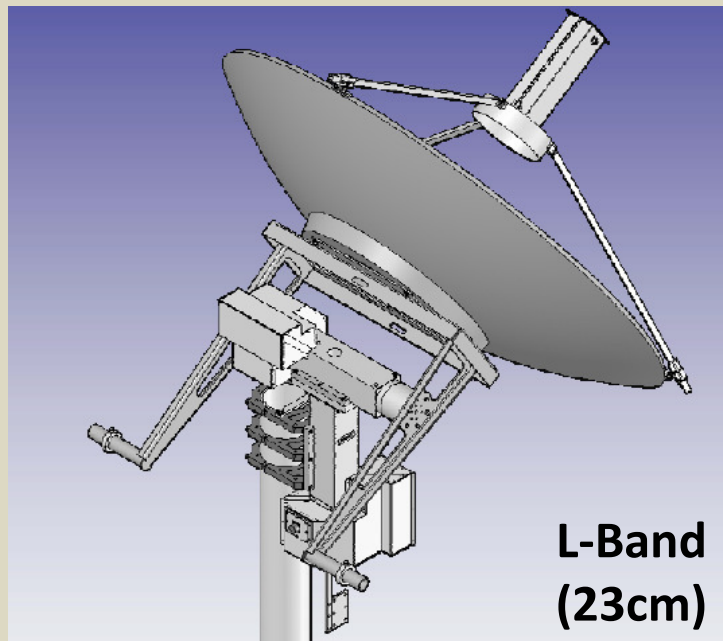
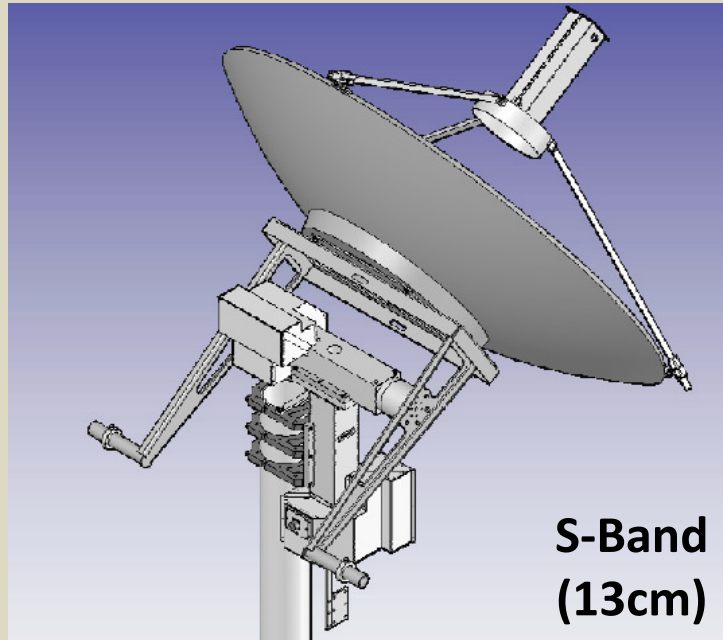
Virginia Tech Cube Satellite Control Facility

Frequency Selection

Amateur Radio Band	Frequency Range	Satellite Sub Band	Note
2 meters (VHF)	144 to 148 MHz	144 to 146 MHz	
70 centimeters (UHF)	430 to 450 MHz	435 to 438 MHz	
23 centimeters (L-Band)	1240 to 1300 MHz	1260 to 1270 MHz	Uplink Only
13 centimeters (S-Band)	2300 to 2310 MHz and 2390 to 2450 MHz	2400 to 2403 MHz	

Virginia Tech Cube Satellite Control Facility

The Antennas



- M² Antennas Inc.
- Circular Polarization
- RHCP/LHCP Sense Selectable
- High Gain, Directional

Virginia Tech Cube Satellite Control Facility

The Antennas



NOTE: This is the exact model we would receive from M2 Antennas Inc. with the AZEL1000 System



Virginia Tech Cube Satellite Control Facility

Cable Runs

LEGEND

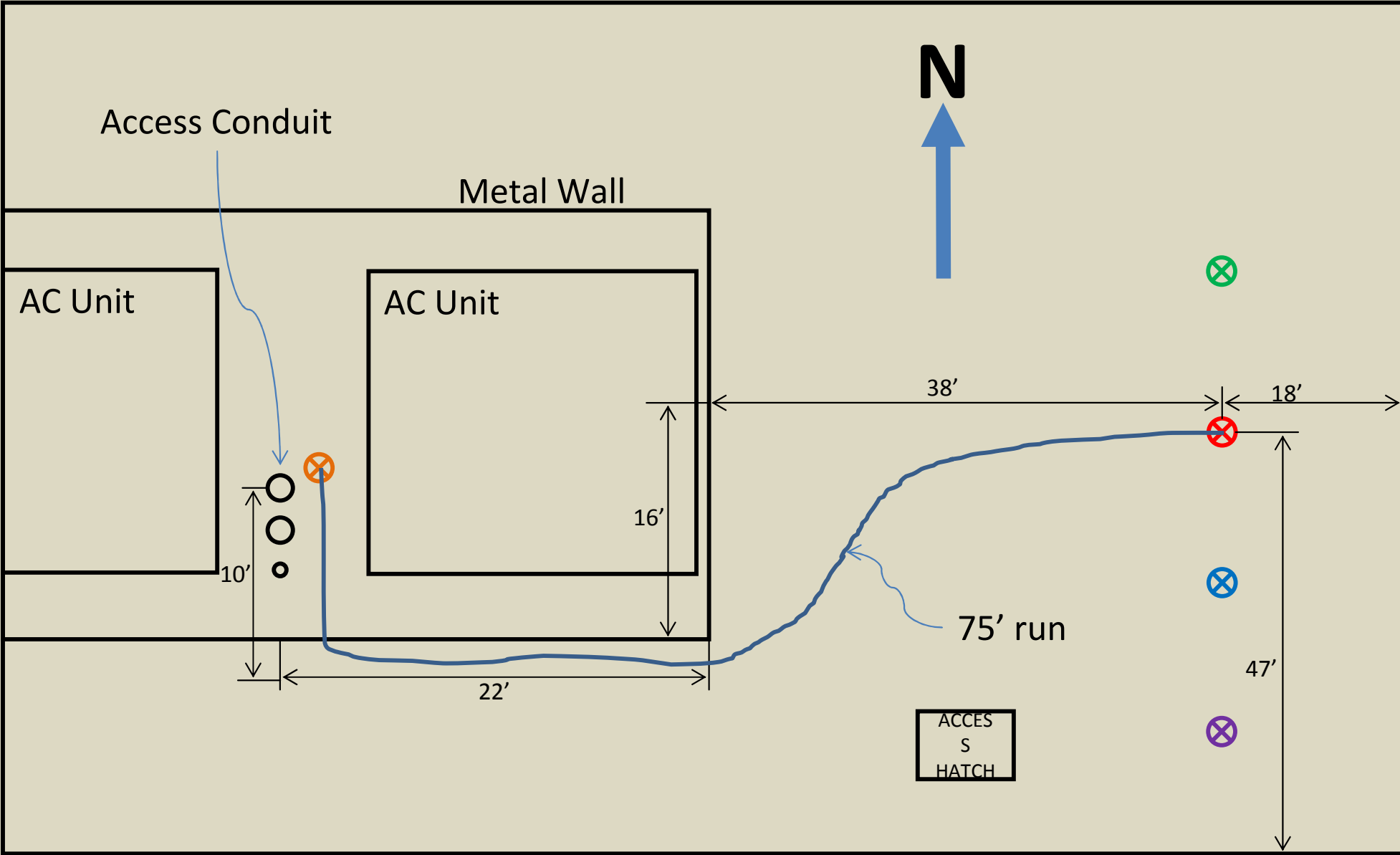
 VHF/UHF Yagi

 23cm Dish

 13cm Dish

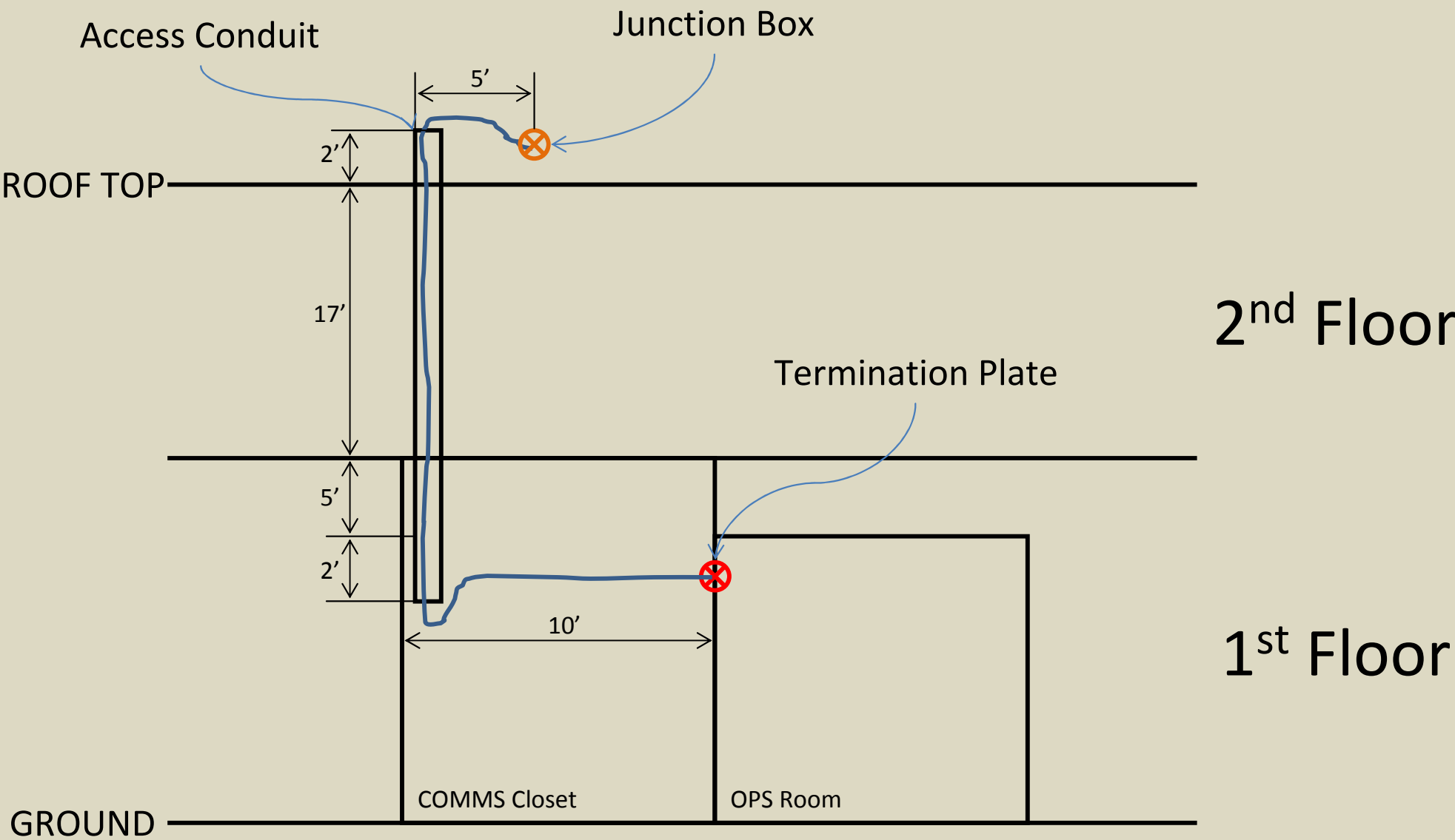
 VSAT terminal

 Junction Box



Virginia Tech Cube Satellite Control Facility

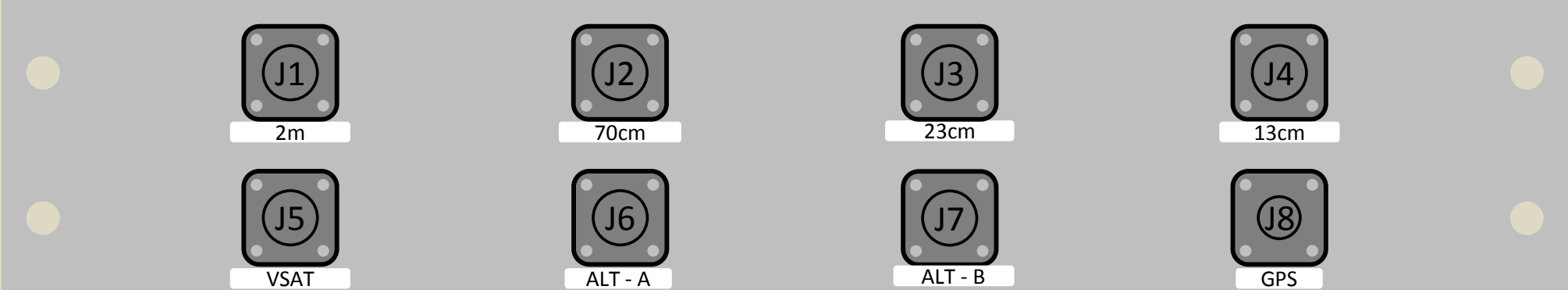
Cable Runs



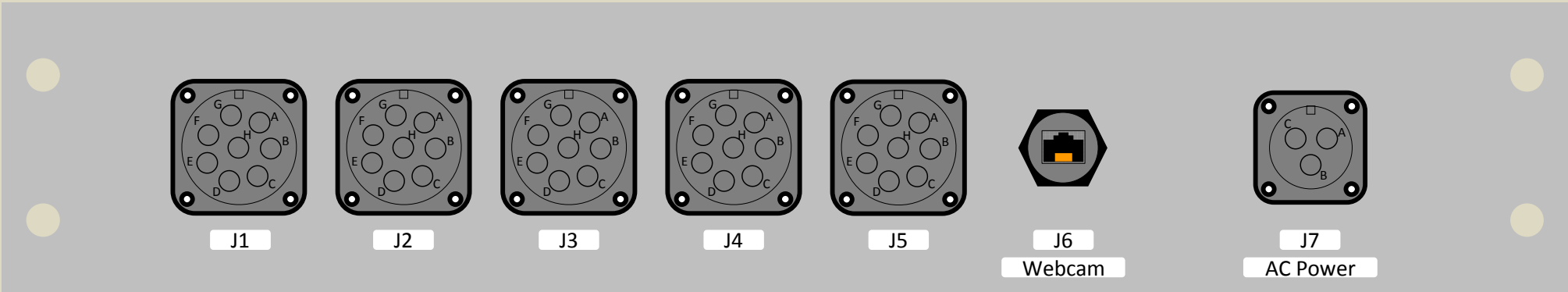
Virginia Tech Cube Satellite Control Facility

Control Room Termination Plates

RF Cable Termination Plate

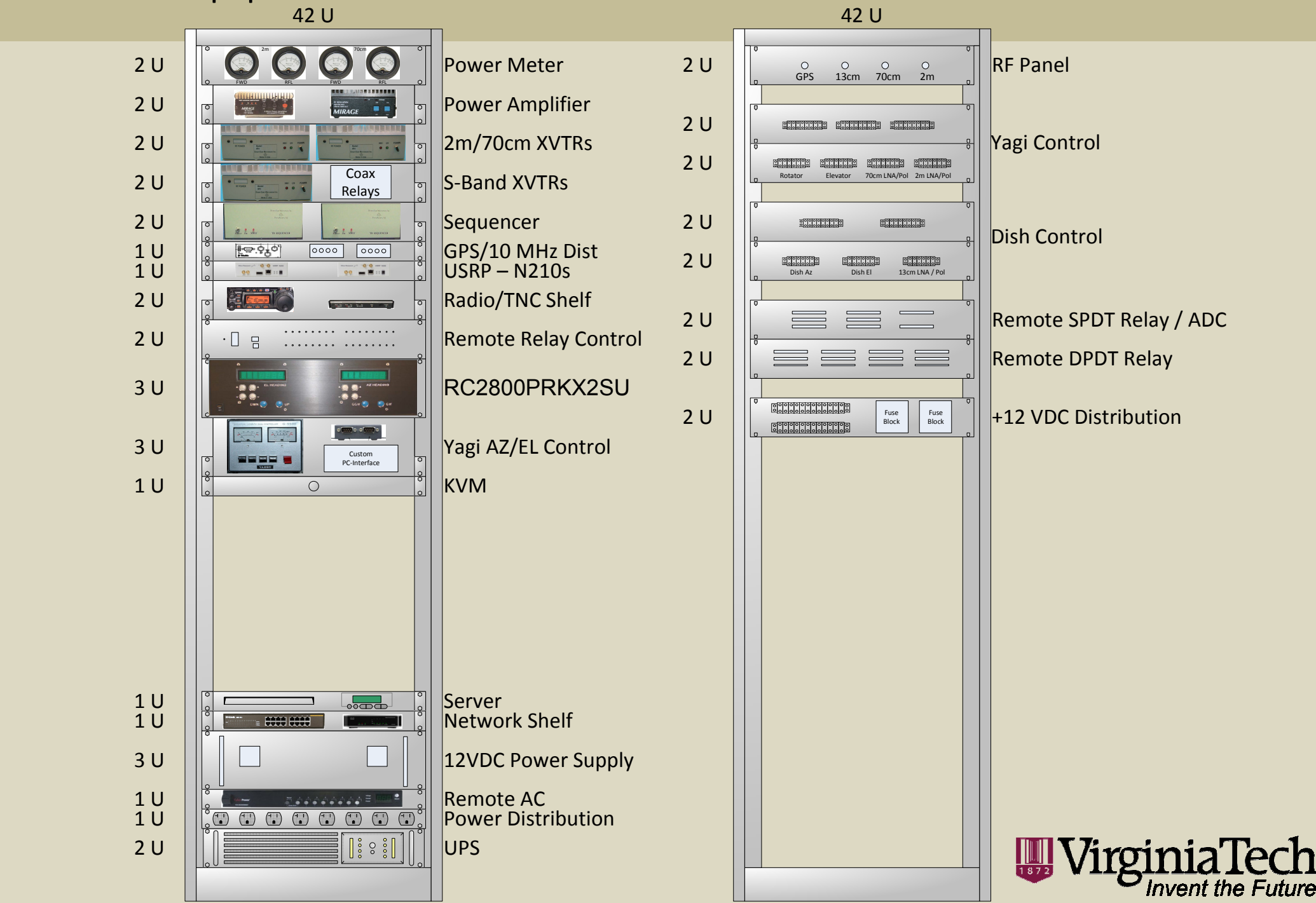


Control Cable Termination Plate



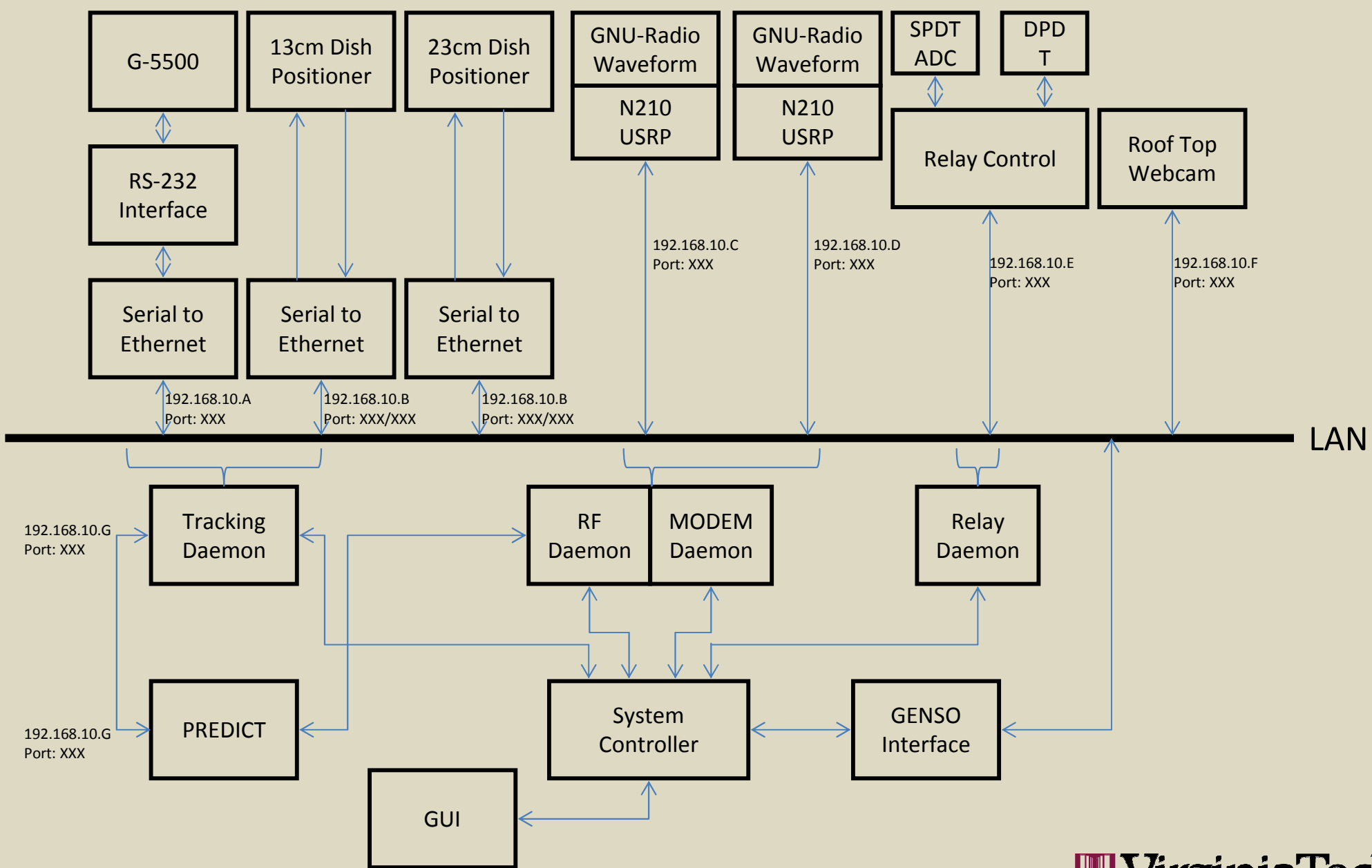
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Rackmount Equipment



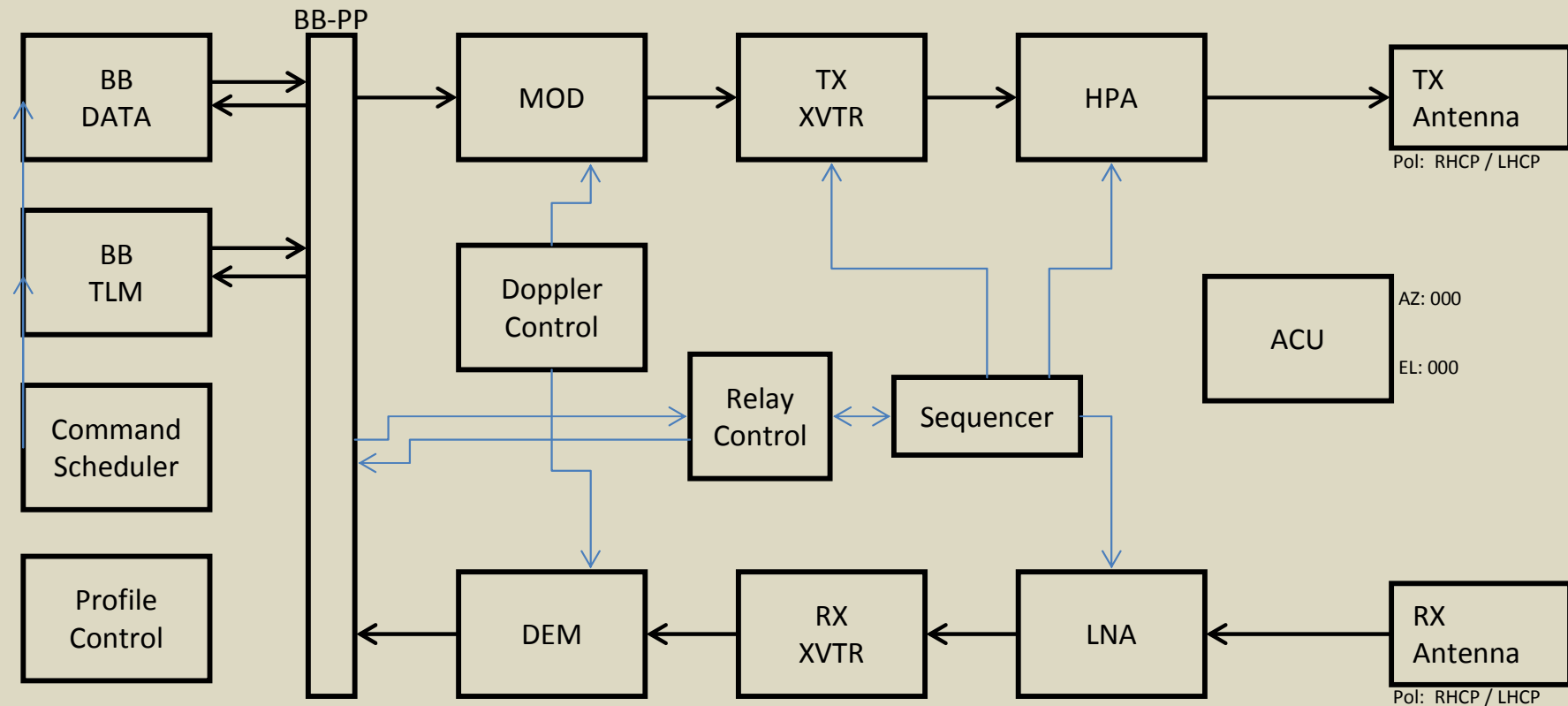
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Network and Control Daemons



Virginia Tech Cube Satellite Control Facility

Graphical User Interface



Questions ...???

